# *Atmospheric Dynamics II*

c. Determine the resulting evolution of the frontal system indicated.

# *Frontal Intensity*

- A measure of strength of density contrast across transition zone.
- Use thickness to estimate intensity..
  - Weak front characterized by a weak thickness gradient in transition zone.
    - A weak thickness gradient would be common in one or more of the following situations:
    - The frontal slope is shallow.

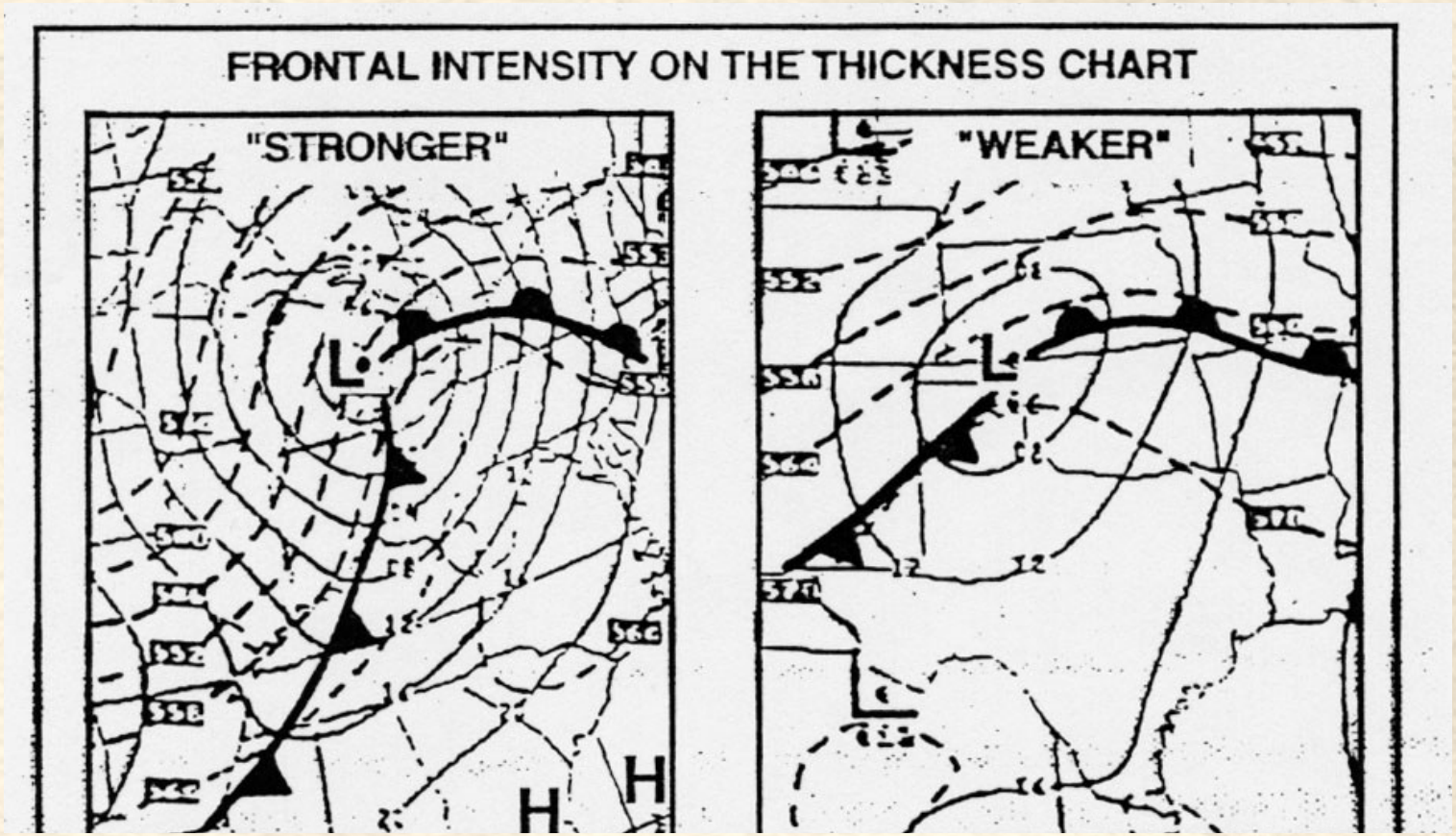
# *Frontal Intensity*

- A weak density contrast exists between air masses
- The front is well removed from the jet stream and upper-level trough.

# *Frontal Intensity*

- Strong front characterized by a strong thickness gradient in transition zone.
  - A strong thickness gradient would be common in one or more of the following situations:
  - The frontal slope is steep.
  - A strong density contrast exists between air masses
  - The front is in close proximity to the jet stream and upper-level trough.

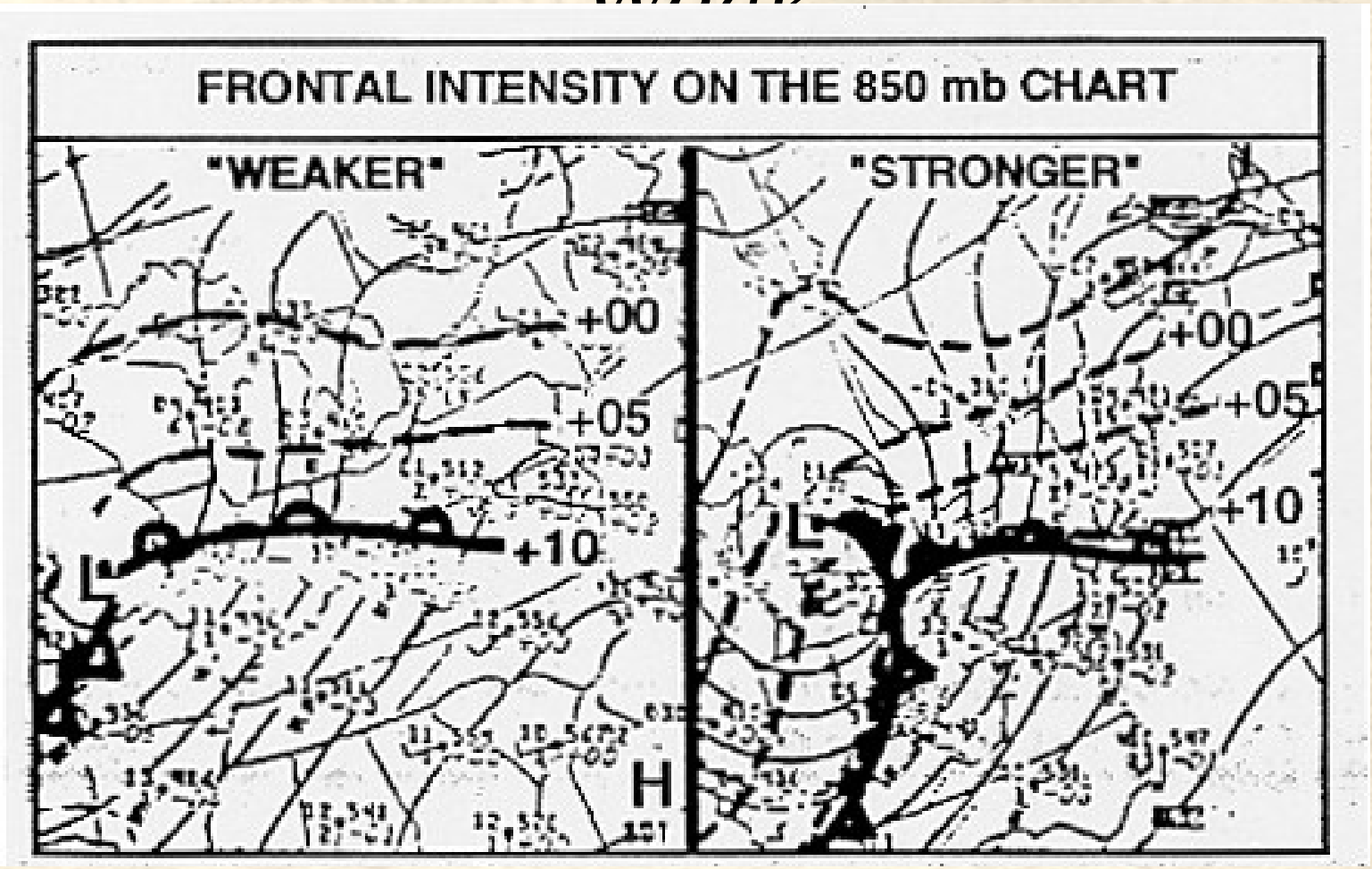
# *Frontal Intensity Estimated Using Thickness - Strong vs Weak*



# *Frontal Intensity*

- Temperature may be used to estimate intensity of front.
  - Weak front is characterized by a weak temperature gradient
  - Strong front is characterized by a strong temperature gradient.

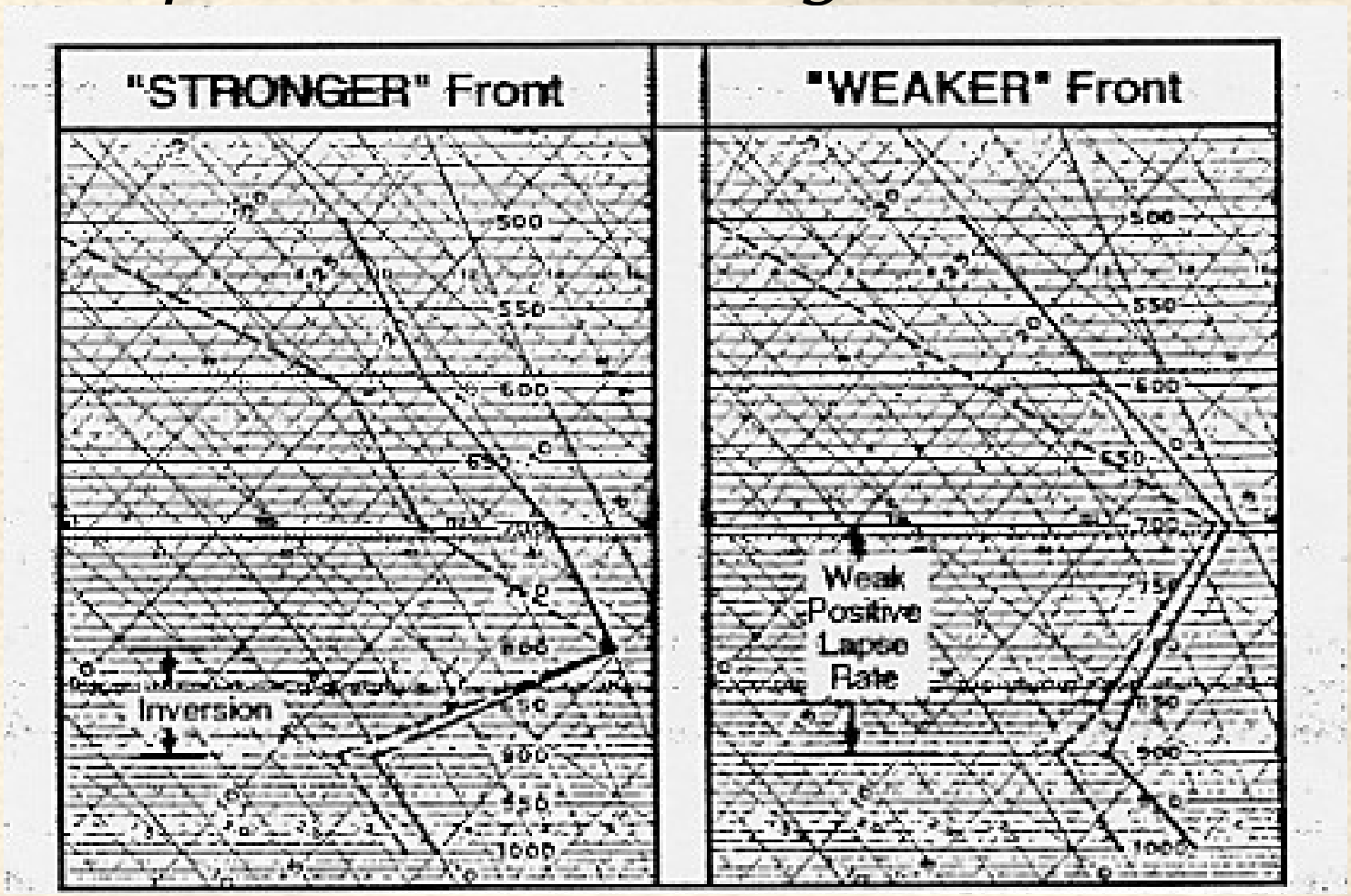
# *Frontal Intensity Estimated Using Temperature - Strong vs Weak*



# *Frontal Intensity*

- Lapse rate through stable layer may indicate frontal intensity.
  - Weak front characterized by a small positive lapse rate
  - Strong front characterized by an inversion (negative lapse rate).

# *Frontal Intensity Estimated Using Lapse Rate - Strong vs Weak*



# *Frontal Intensity*

- Most important aspect is monitoring change in frontal intensity.

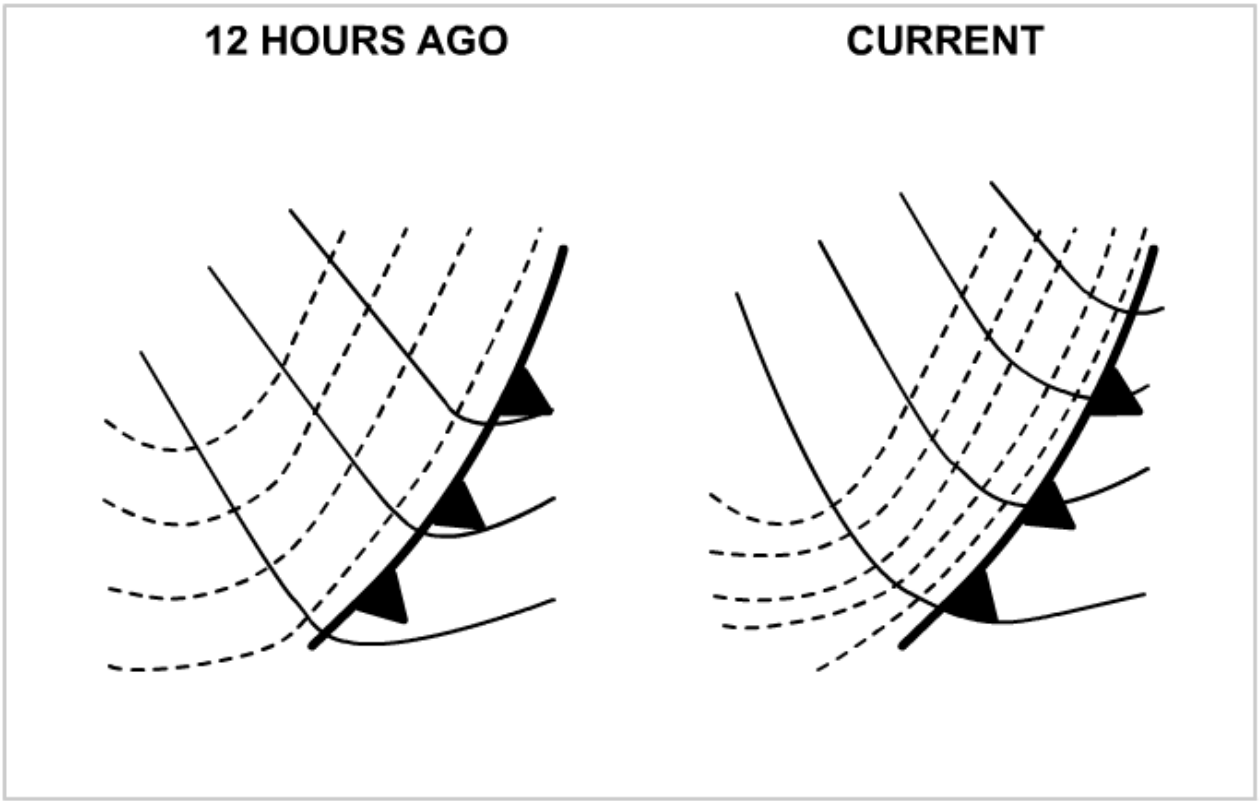
# *Frontal Intensity Change Terminology*

- Frontogenesis - Creation of new front, or increase in intensity of existing front.
  - Thickness packing increases.
  - Temperature gradient increases.
  - Inversion develops or becomes stronger.
  - Increasing convergence and lifting often occur in the frontal zone which will increase the likelihood of clouds and precipitation there.

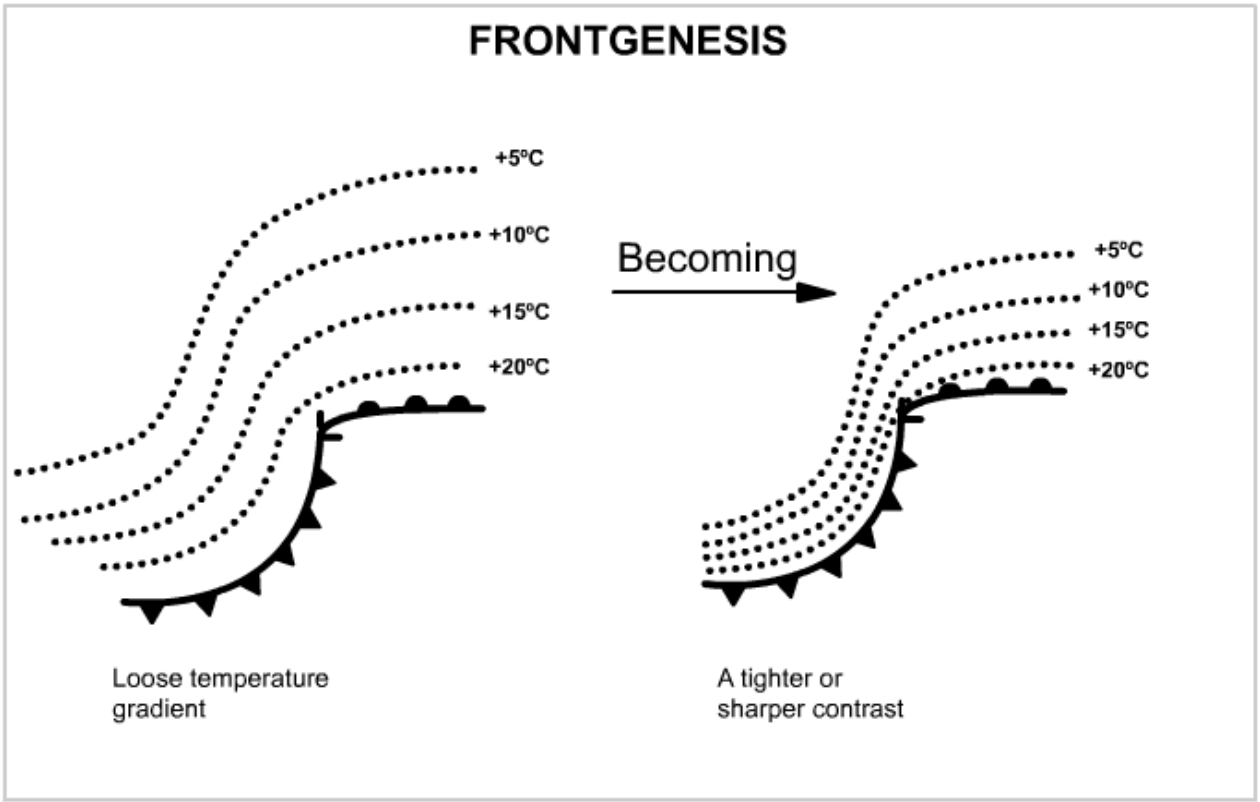
# *Frontal Intensity Change Terminology*

- Frontolysis - Total dissipation of front or decrease in intensity of an existing front.
  - Thickness packing decreases.
  - Temperature gradient decreases.
  - Lapse rate weakens or dissipates.
  - Decreasing convergence and lifting (or increasing divergence and subsidence) often occur in the frontal zone which will decrease (or totally eliminate) the likelihood of clouds and precipitation there.

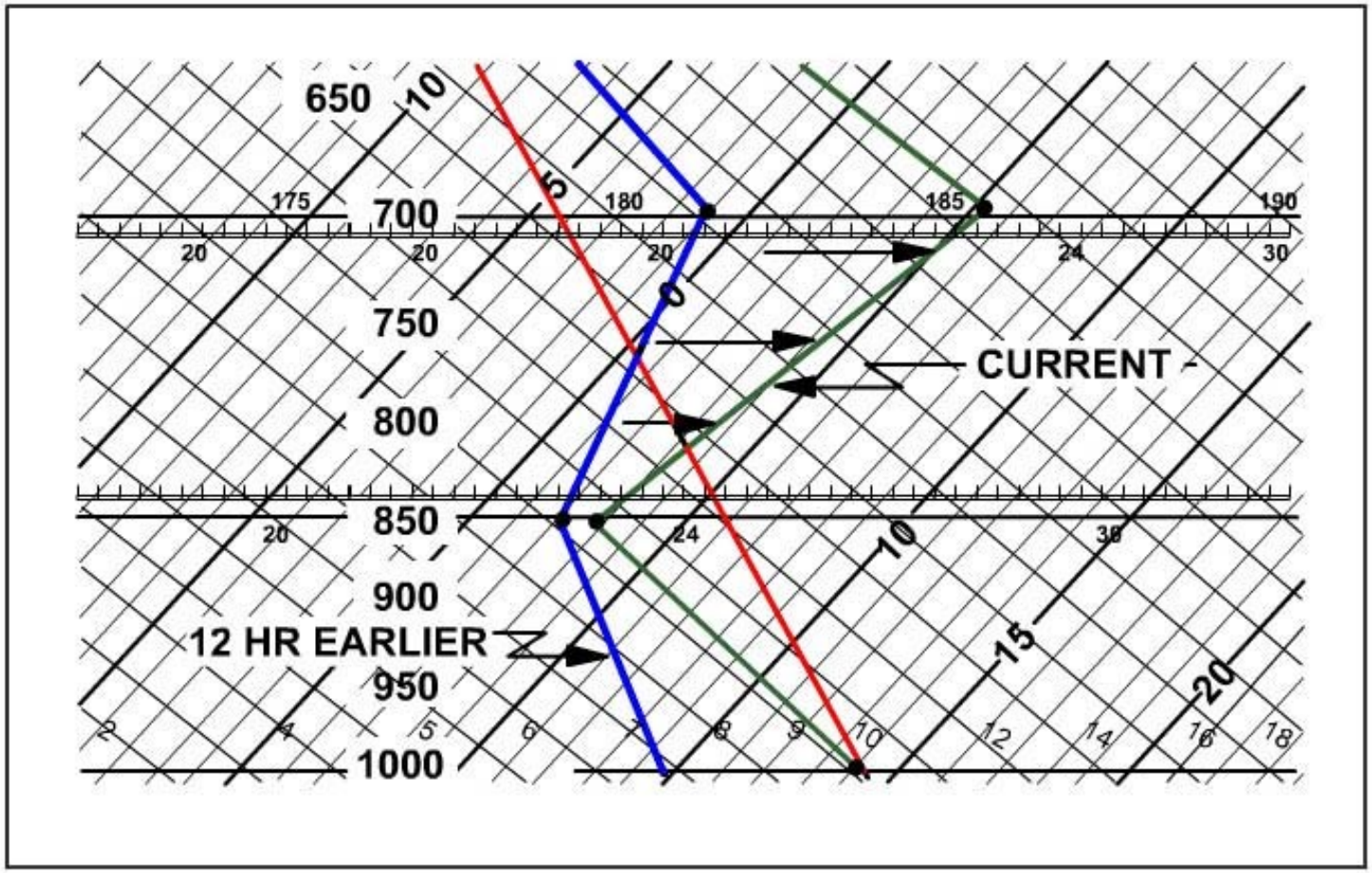
# *Frontogenesis on the Thickness Chart*



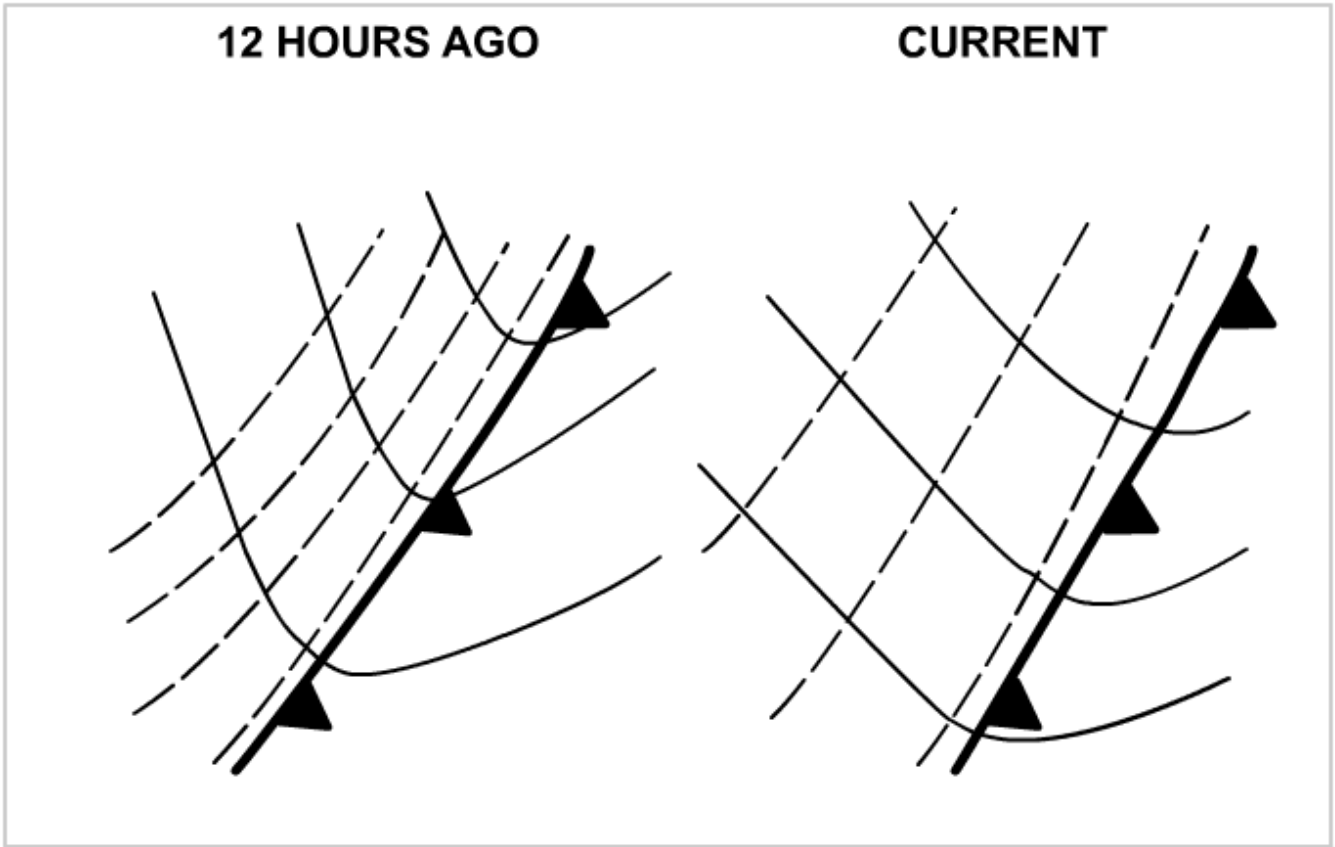
# *Frontogenesis – temperature gradient increases*



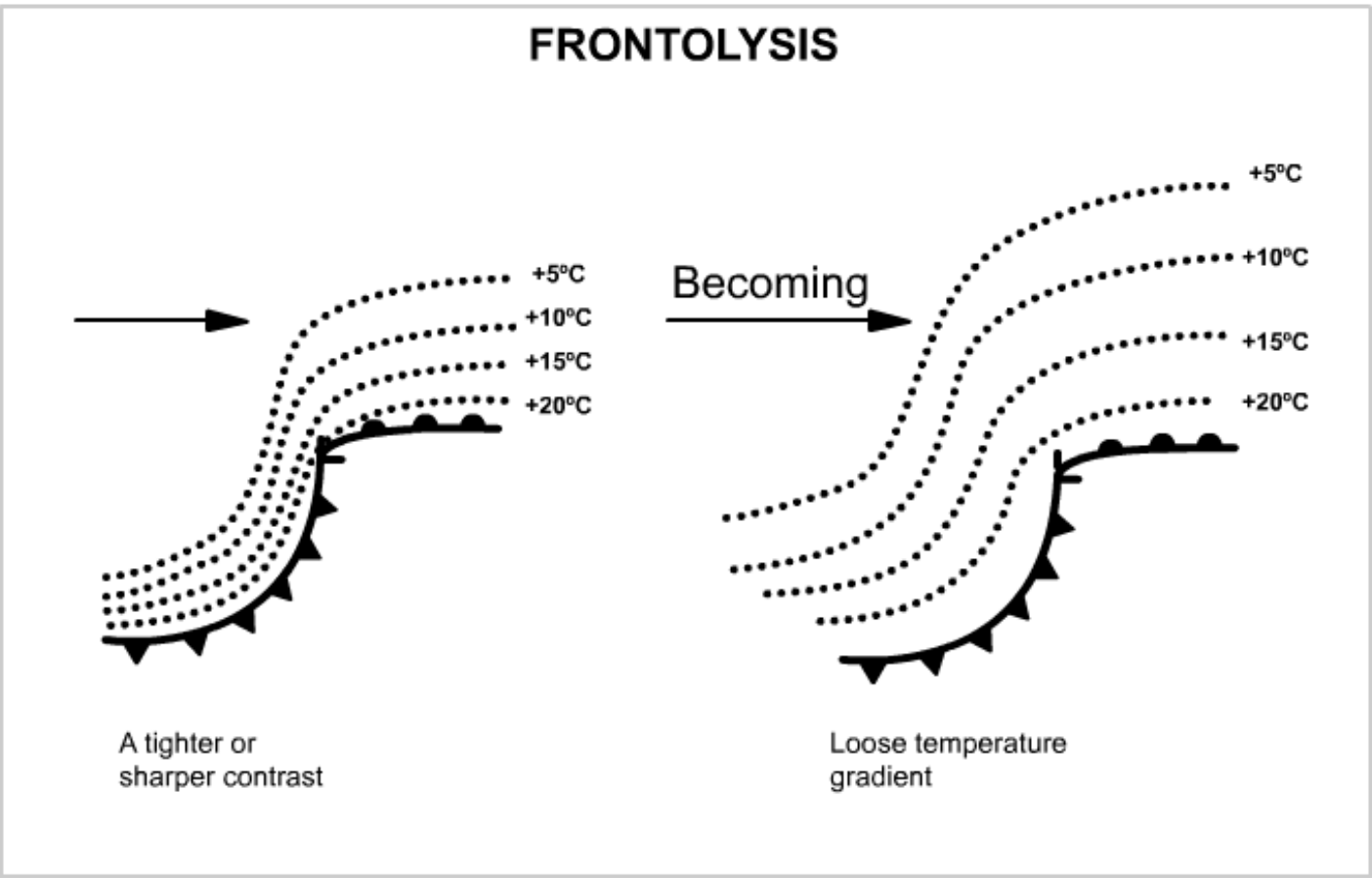
# *Frontogenesis on the Skew-T*



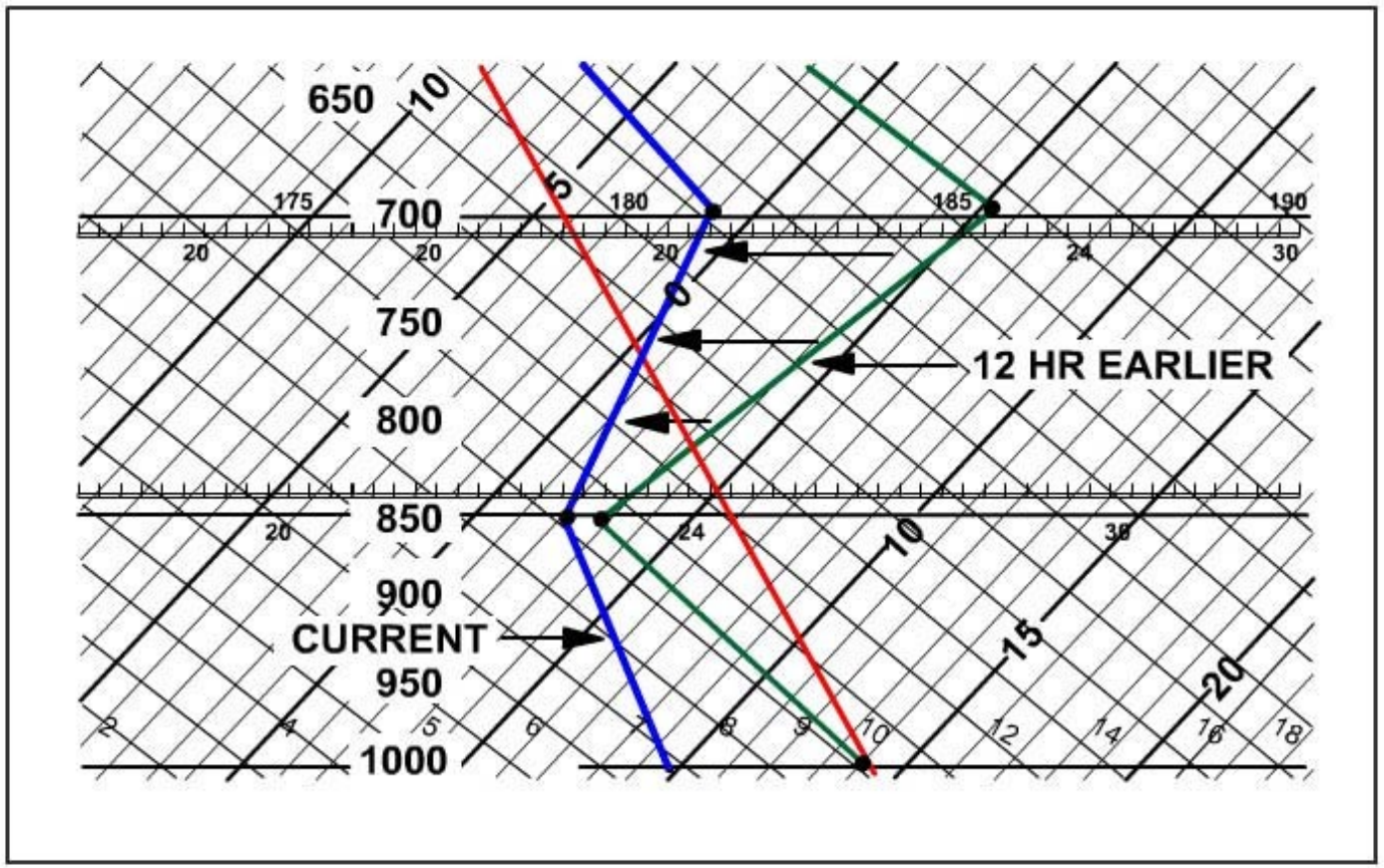
# *Frontolysis on the Thickness Chart*



# *Frontolysis– temperature gradient decreases*



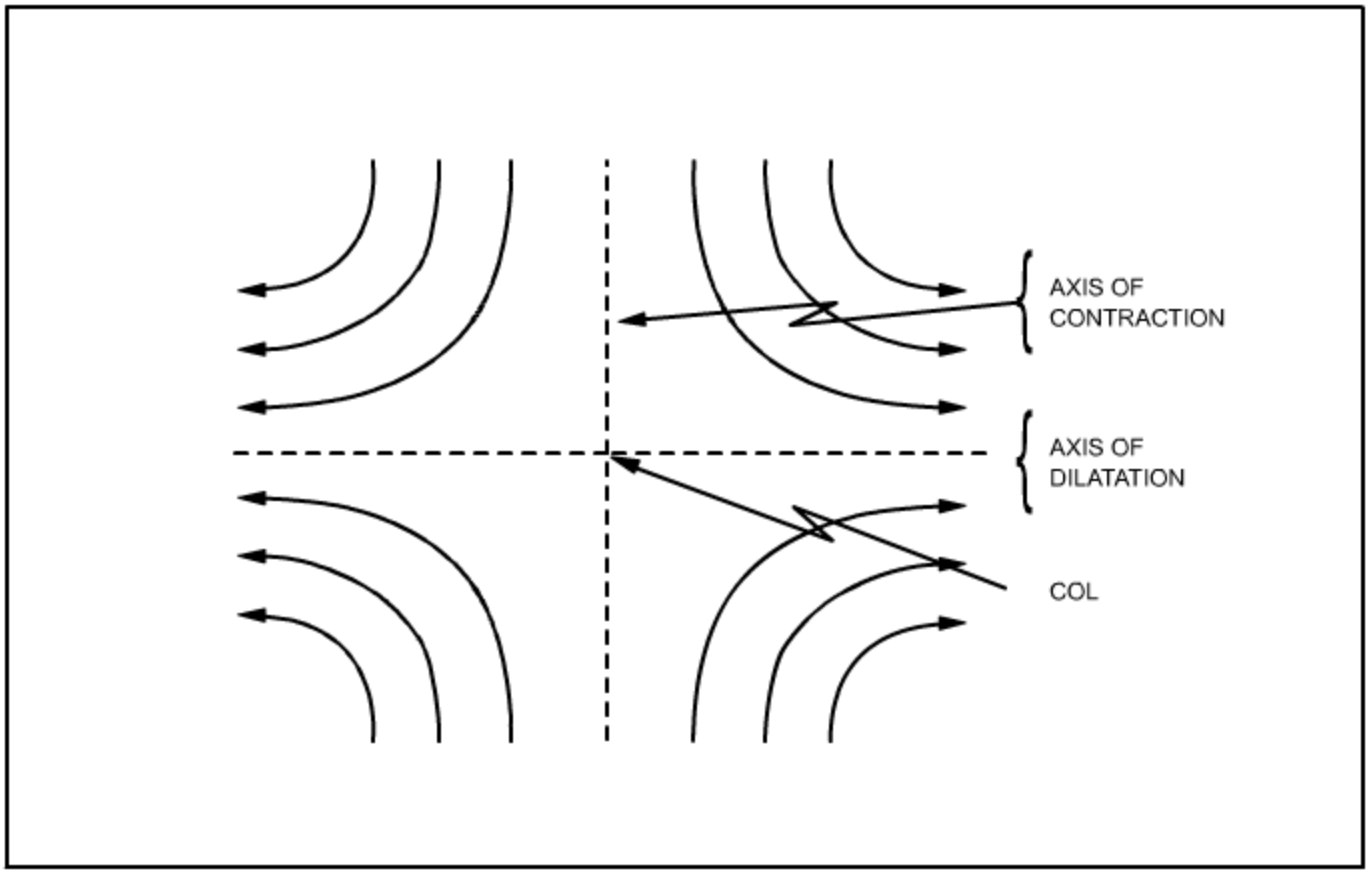
# *Frontolysis on the Skew-T*



# *Frontal Intensity Change Terminology*

- Deformation Zone - Flow pattern characterized by stretching or shearing of air parcels by wind. Deformation zones exist at all levels of atmosphere.
  - Col (Neutral Point) - Center of deformation zone.
  - Axis of Dilatation - Axis of most rapid stretching.
  - Axis of Contraction - Axis of most rapid shrinking.

# *The Deformation Zone*



# *Frontal Intensity Change Terminology*

- In a PURE deformation zone NEITHER CONVERGENCE NOR DIVERGENCE EXIST.
  - Just as fast as mass is moving along axis of contraction, mass is being removed along axis of dilatation.
  - Remember, speed divergence and confluence offset (i.e., oppose) each other and vice versa. This can be seen in the divergence equation studied in Dynamics I:

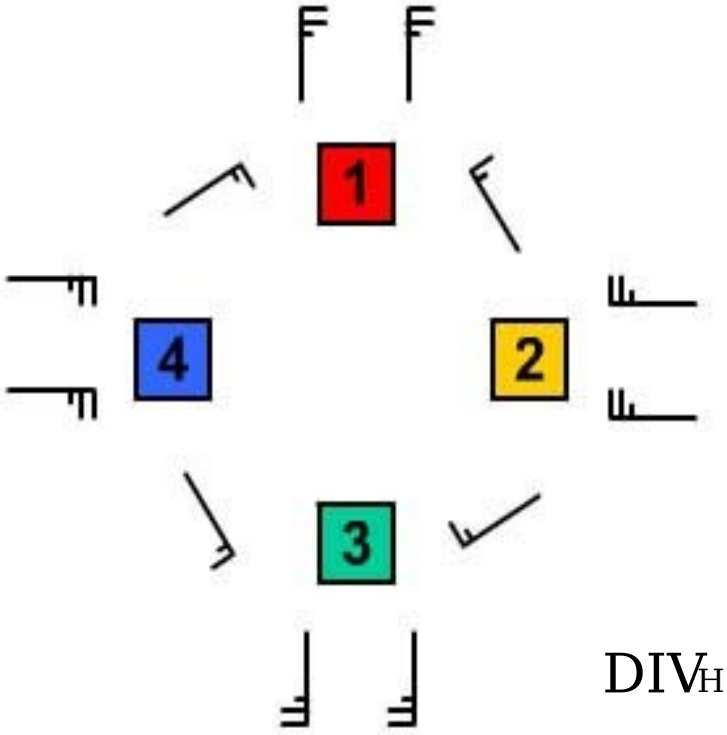
$$DIV_H = \underbrace{\frac{\Delta V}{\Delta s}}_{(A)} + \underbrace{\frac{V \Delta \alpha}{\Delta n}}_{(B)}$$

# *Frontal Intensity Change Terminology*

$$DIV_H = \frac{\Delta V}{\Delta s} + \frac{V\Delta\alpha}{\Delta n}$$

- Removal of mass from axis of contraction by diffluence (Term B = “+”) is exactly offset by speed convergence (Term A = “-“). Result: $DIV_H = 0$.
- Addition of mass along axis of dilatation by confluence (Term B = “-”) is exactly offset by speed divergence (Term A = “+“). Result: $DIV_H = 0$.

$$\mathbf{DIV_H} = \frac{\Delta \mathbf{V}}{\Delta \mathbf{s}} + \frac{\mathbf{V}\Delta\alpha}{\Delta \mathbf{n}}$$




IN A PURE DEFORMATION ZONE,
NO CONVERGENCE OR DIVERGENCE OCCUR.

AT POINTS 1 & 3:

Diffluence offsets Speed Convergence

$$\frac{\Delta V}{\Delta s} = -$$

$$\frac{V\Delta\alpha}{\Delta n} = +$$

AT POINTS 2 & 4:

Confluence offsets Speed Divergence

$$\frac{\Delta V}{\Delta s} = +$$

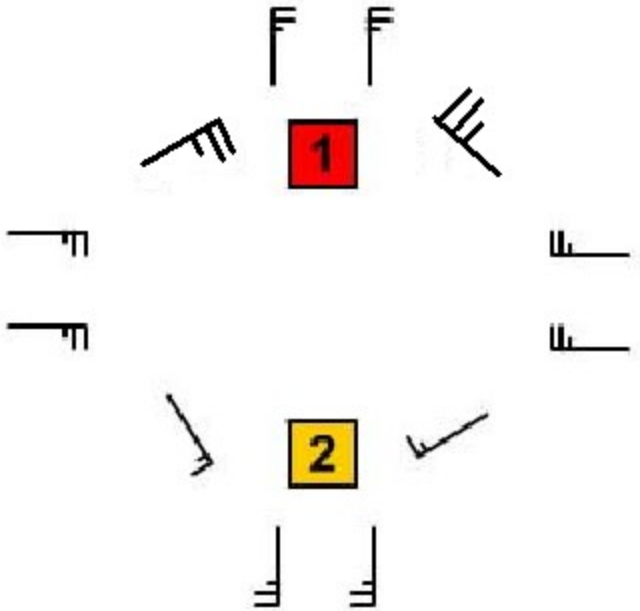
$$\frac{V\Delta\alpha}{\Delta n} = -$$

$$DIV_H = \frac{\Delta V}{\Delta s}(+) + \frac{V\Delta\alpha}{\Delta n}(-) = 0$$

$$DIV_H = \frac{\Delta V}{\Delta s}(-) + \frac{V\Delta\alpha}{\Delta n}(+) = 0$$

$$DIV_H = 0$$

$$DIV_H = 0 + \frac{V\Delta\alpha}{\Delta n}(+) = +$$




AT POINT 1: $\frac{\Delta V}{\Delta s} = 0$

Diffluence
+ No Change in Speed $\frac{V\Delta\alpha}{\Delta n} = +$
= Divergence

$DIV_H = +$

AT POINT 2

Diffluence
+ Speed Convergence $\frac{\Delta V}{\Delta s} = -$
=No Divergence

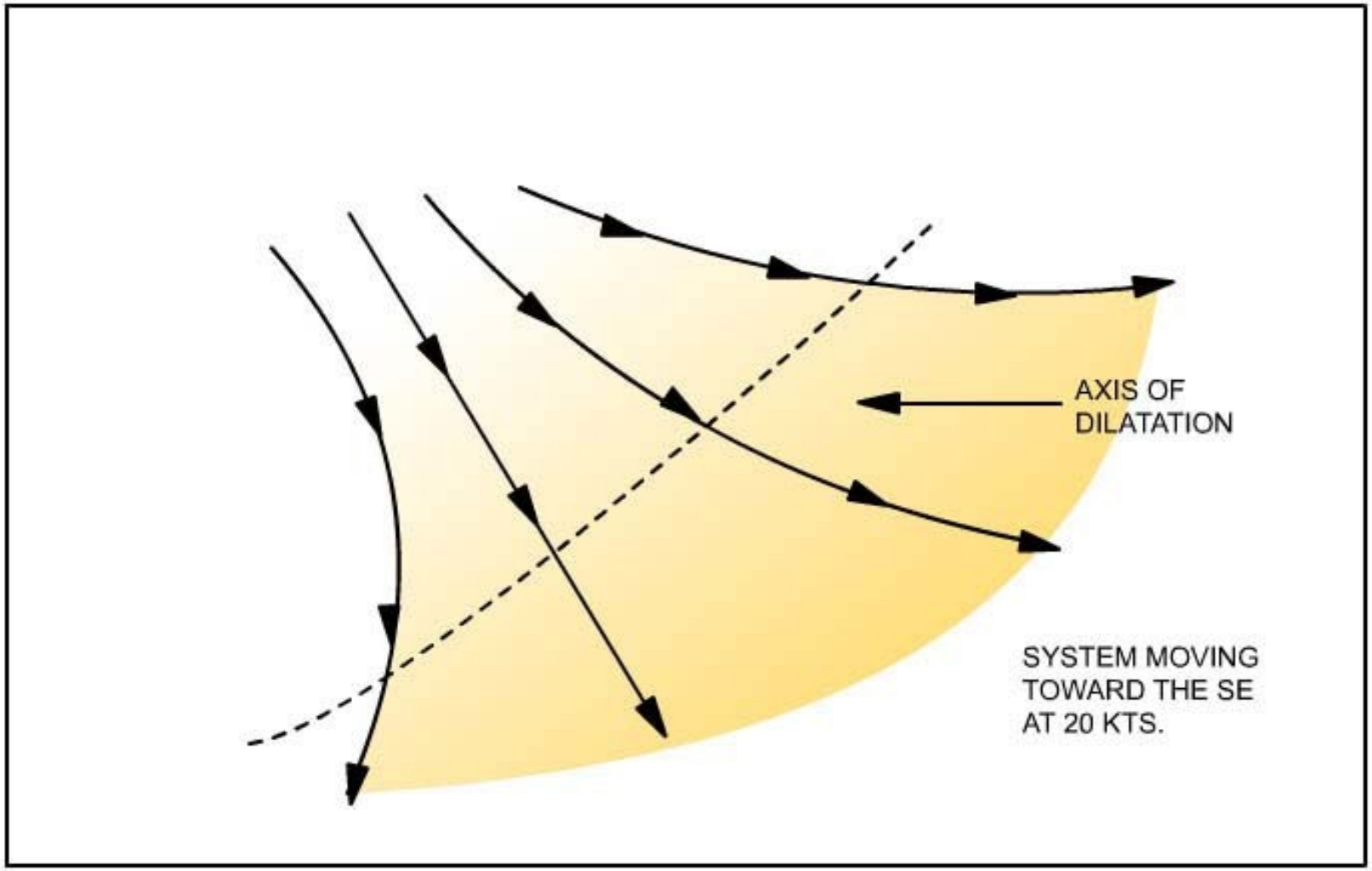
$\frac{V\Delta\alpha}{\Delta n} = +$

$$DIV_H = \frac{\Delta V}{\Delta s}(-) + \frac{V\Delta\alpha}{\Delta n}(+) = 0$$

$DIV_H = 0$

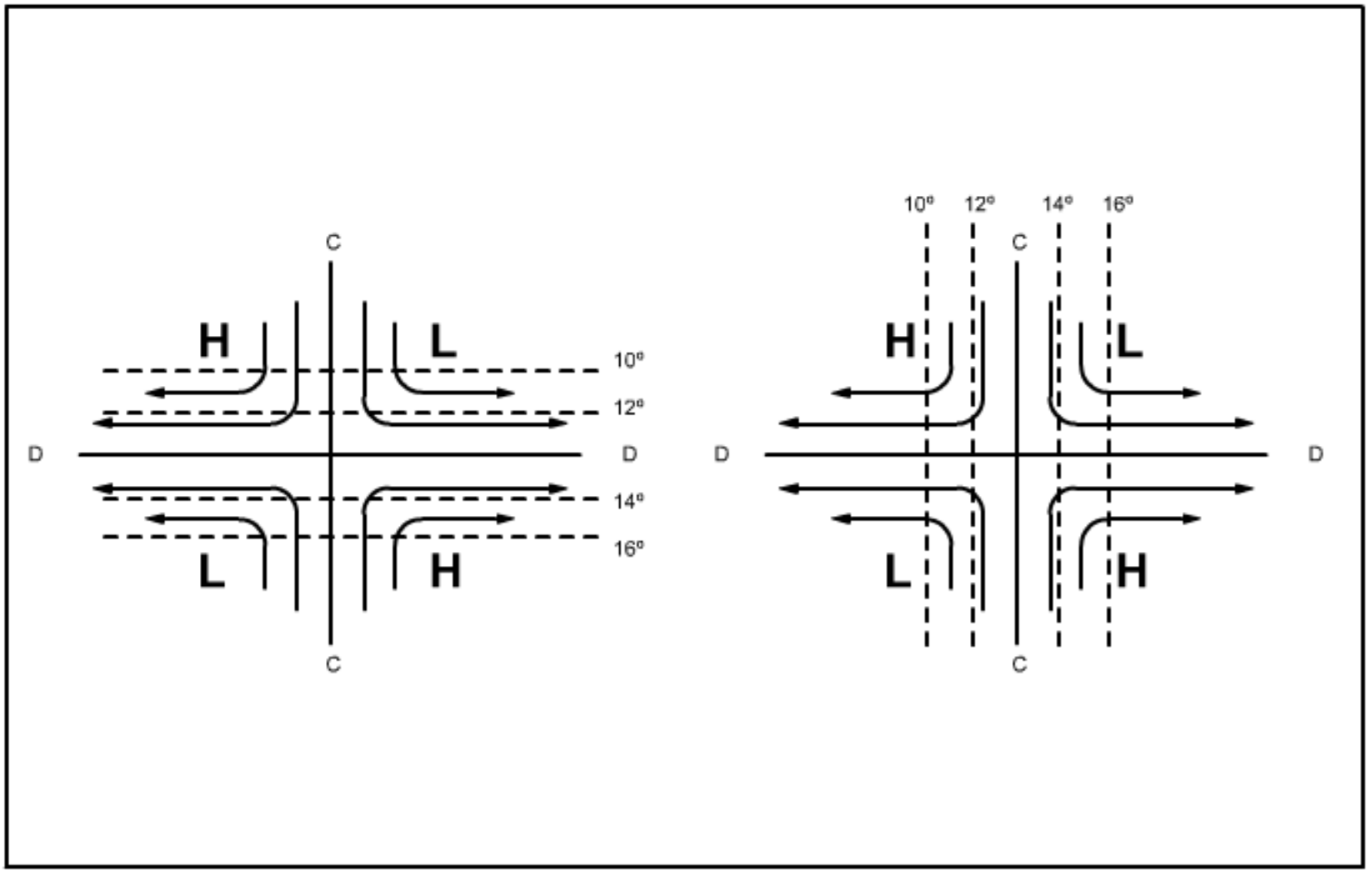
# *Frontal Intensity Change Terminology*

- The presence or absence of (or changes in) cloudiness and precipitation are good indicators of whether convergence or divergence is occurring (or increasing or decreasing) in the frontal zone.
- Deformation zones do not always appear classical.
  - Stationary systems will appear classical.
  - Moving systems will appear as diffluence or confluence.


AXIS OF
DILATATION
SYSTEM MOVING
TOWARD THE SE
AT 20 KTS.

# *Factors Affecting Frontal Intensity*

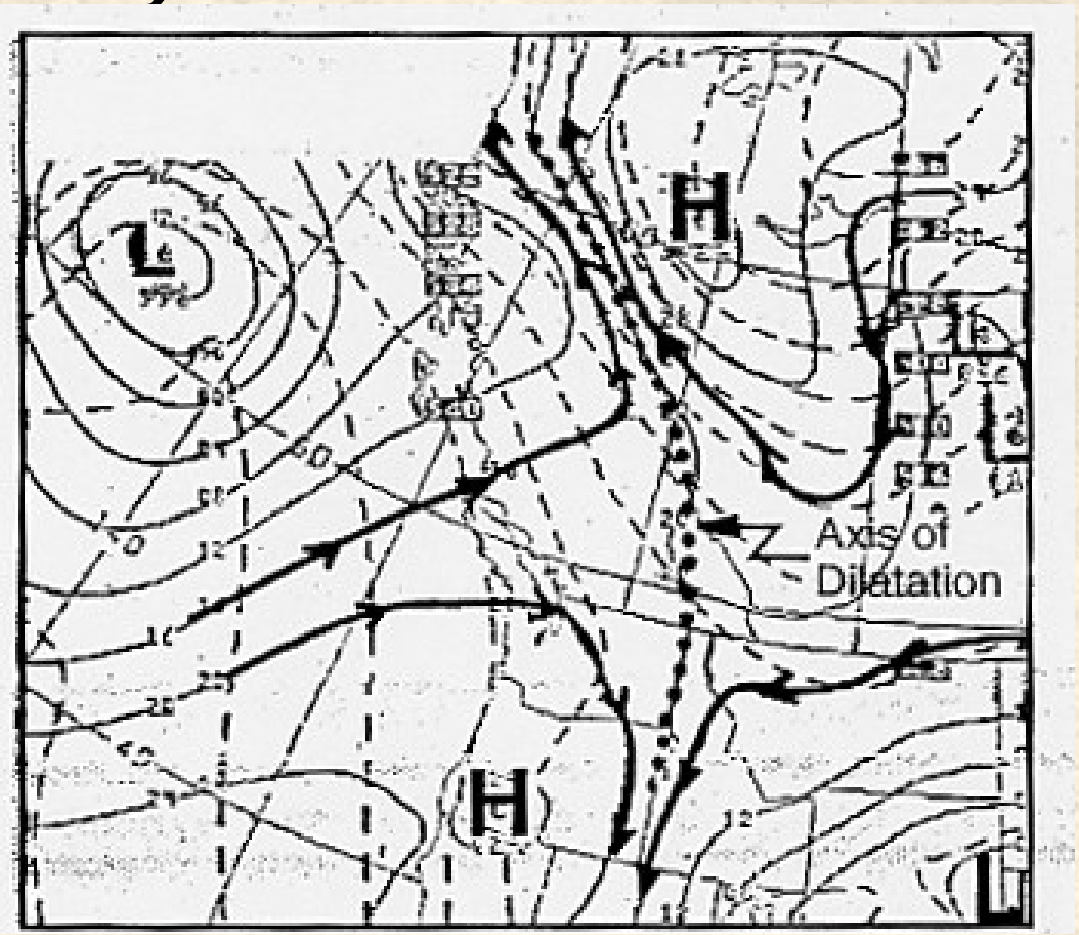
- Low-level Deformation Zones
  - Low-level deformation zones can favor either frontogenesis or frontolysis.
    - If isotherms and/or thickness lines are parallel to axis of dilatation, frontogenesis is favored.
    - If isotherms and/or thickness lines are perpendicular to the axis of dilatation, frontolysis is favored.


C
H
L
10°
12°
D
D
14°
16°
L
H
C
10°
12°
14°
16°
C
H
L
D
D
L
H
C

# *Factors Affecting Frontal Intensity*

- Evaluating Deformation Zones and Frontal Intensity Change on Charts
  - If angle is less than 45° between isotherms and axis of dilatation, frontogenesis will occur.
  - Smaller angle indicates greater convergence of isotherms (or thickness contours), stronger thermal gradient, and thus stronger support for frontogenesis.

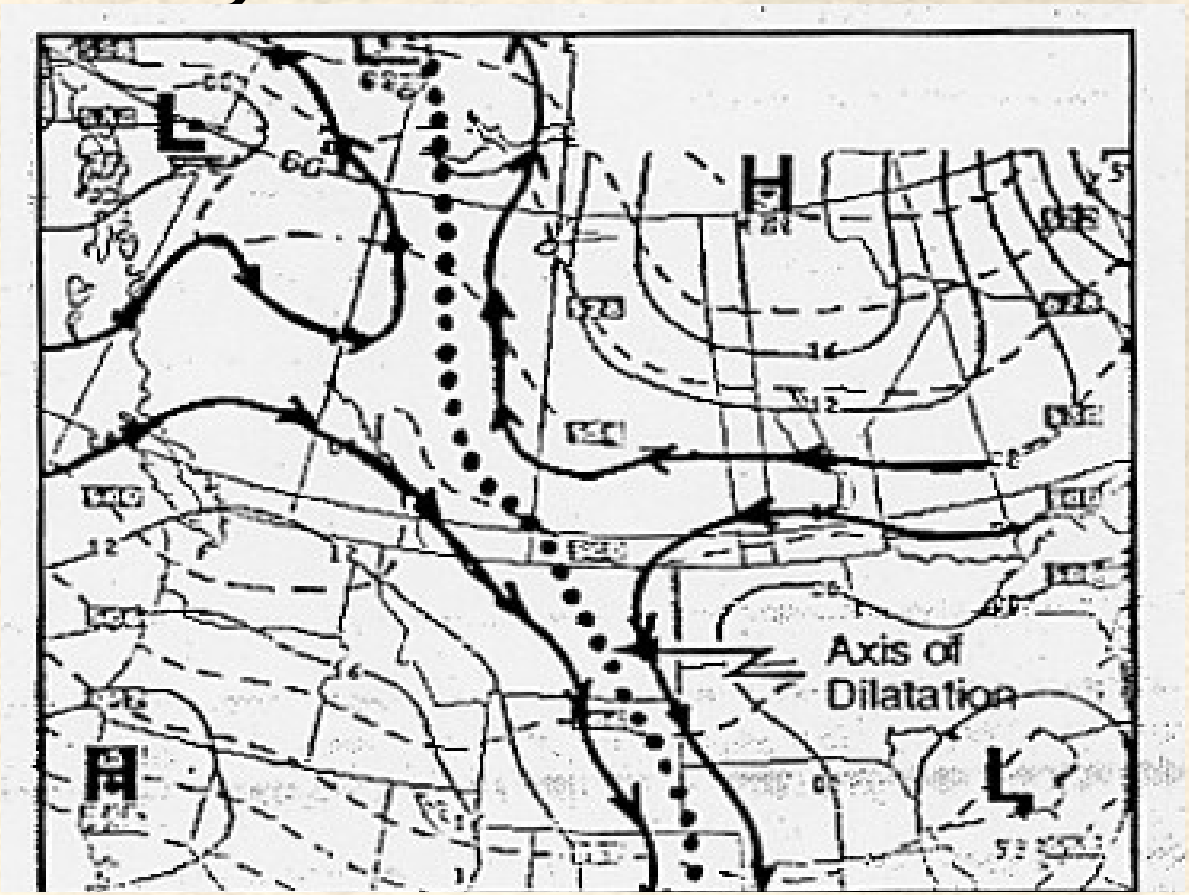
# *Frontogenesis in a Deformation Zone*



# *Factors Affecting Frontal Intensity*

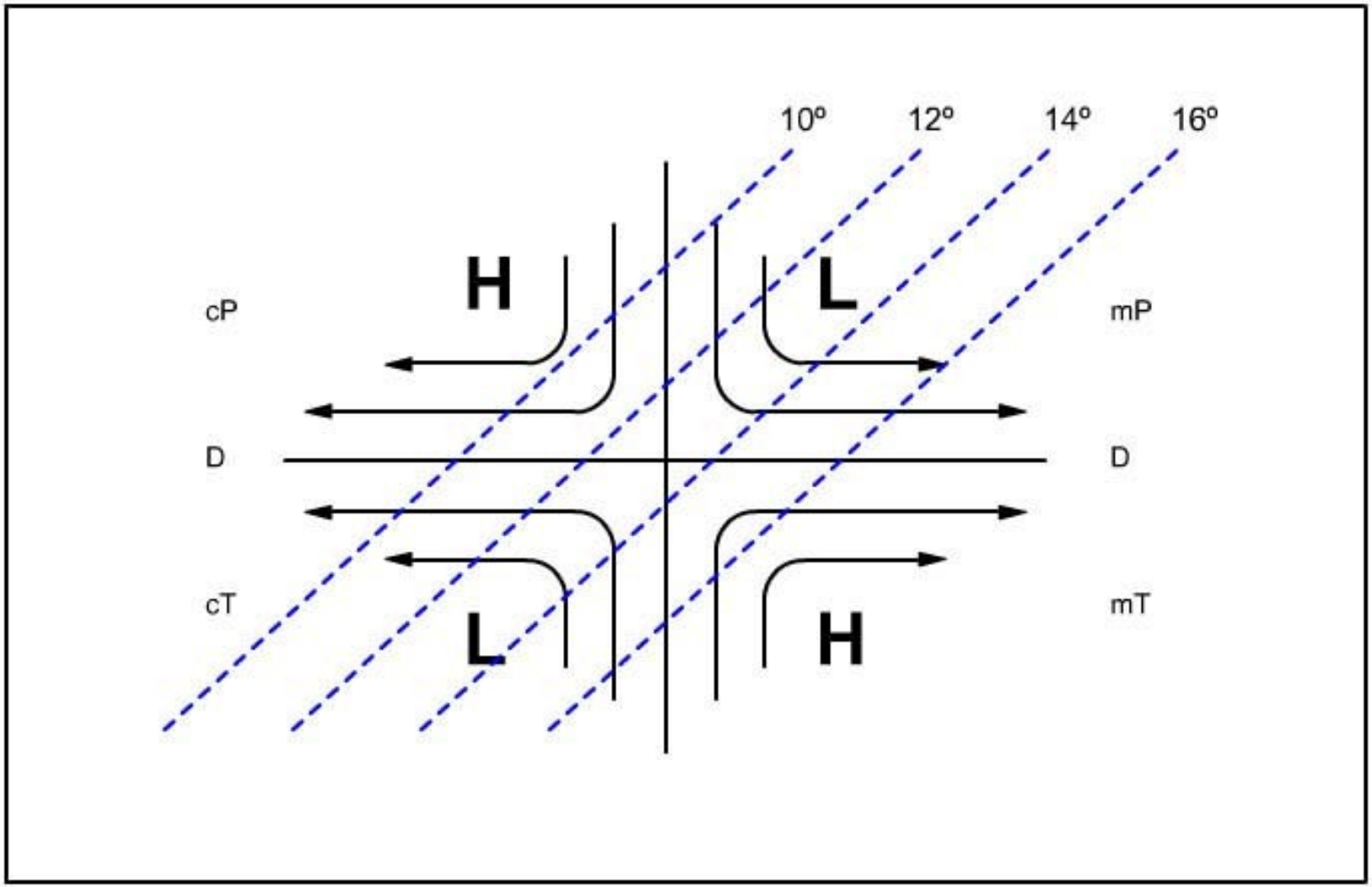
- If angle is more than 45° between isotherms and axis of dilatation, frontolysis will occur.
- Larger angle indicates greater divergence of isotherms (or thickness contours), weaker thermal gradient, and thus stronger support for frontolysis.
- Degree to which frontogenesis/frontolysis is favored will vary throughout the deformation zone.

# *Frontolysis in a Deformation Zone*



# *Factors Affecting Frontal Intensity*

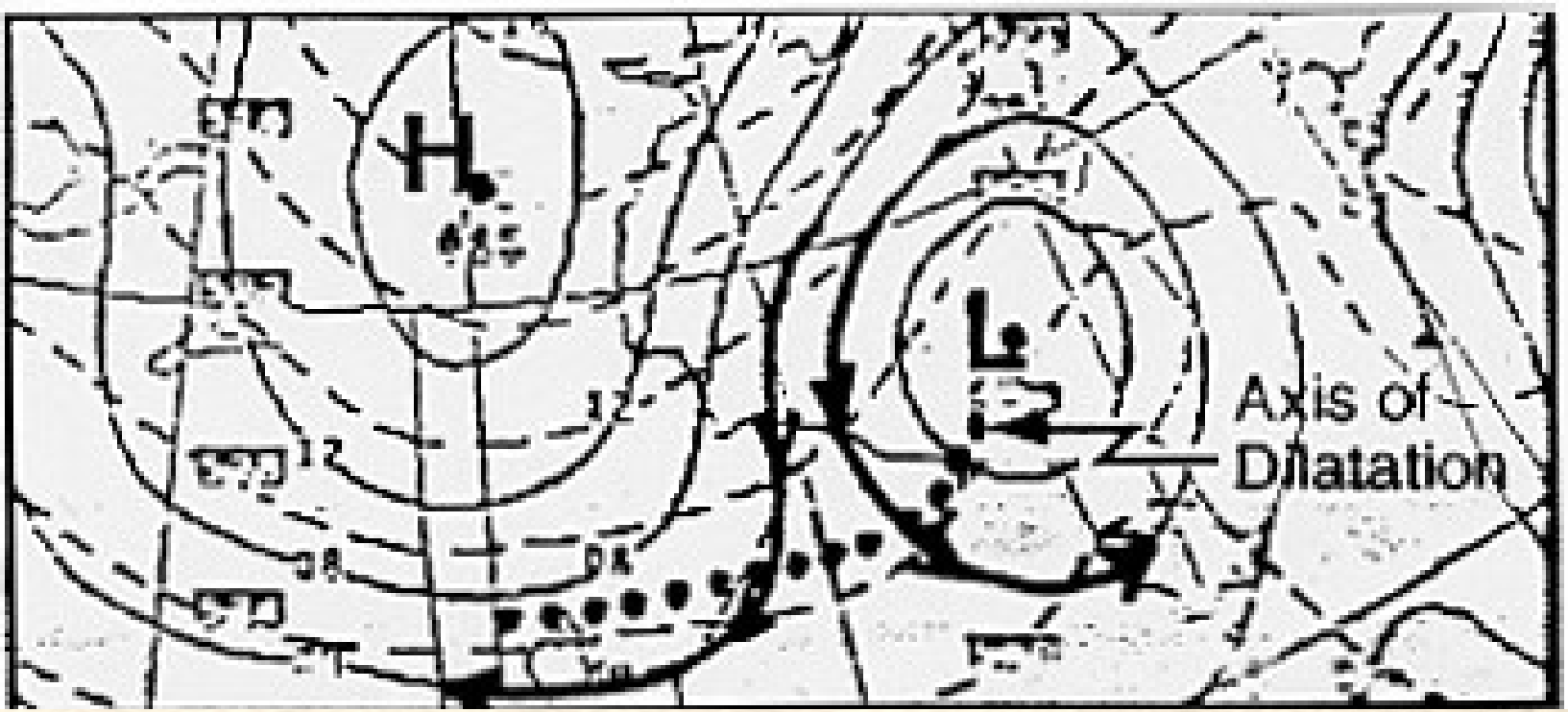
- Isotherms are rarely either perfectly parallel or perpendicular.
  - An angle of 45˚ between isotherms and/or thickness lines and axis of dilatation is critical for determining whether frontogenesis **of** or frontolysis is favored.
  - As shown in the figure, this exact angle of 45˚, supports neither frontogenesis or frontolysis.


10°
12°
14°
16°
H
L
cP
mP
D
D
cT
mT
L
H

# *Factors Affecting Frontal Intensity*

- Strongest contribution of deformation to frontogenesis usually occurs in moving systems.

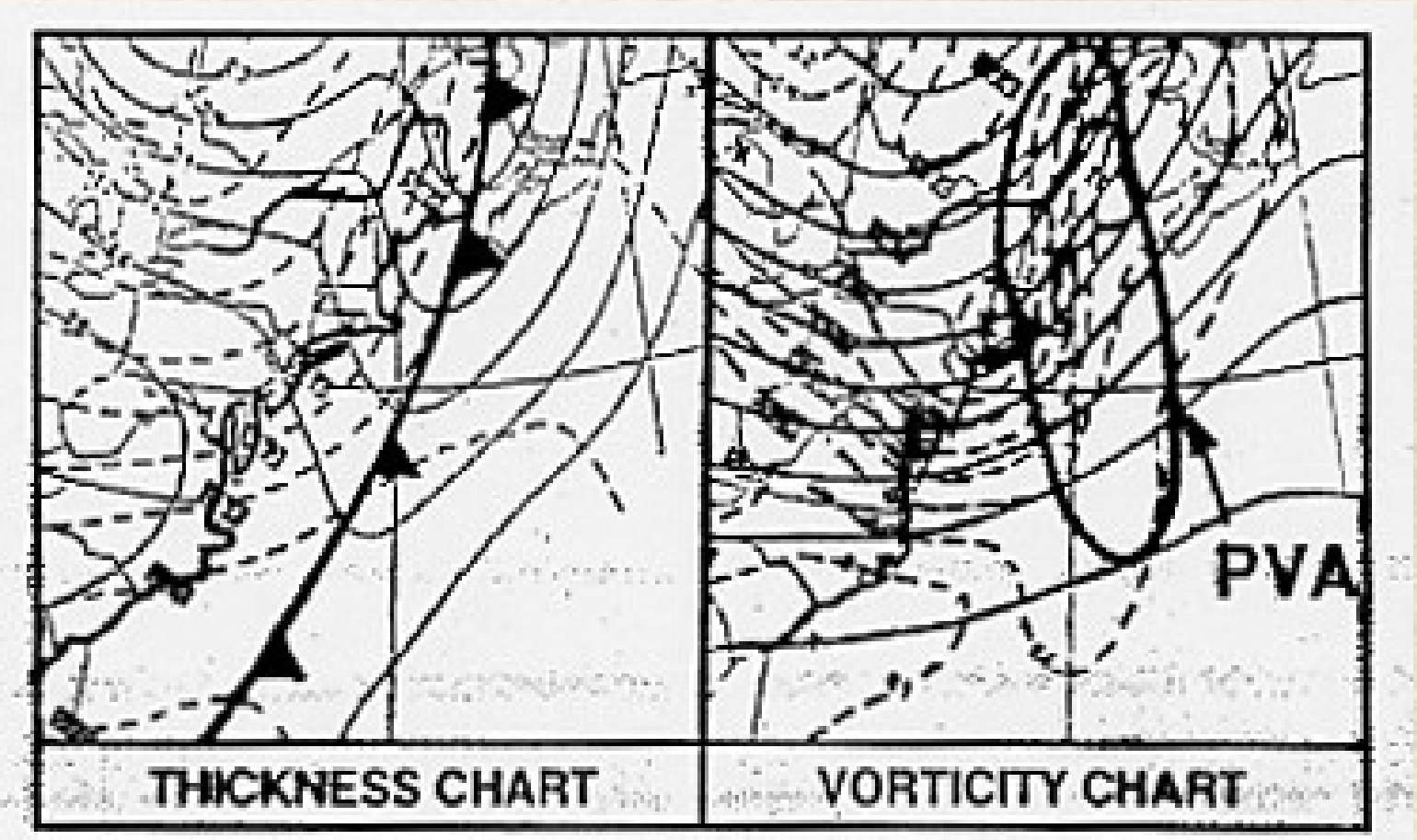
# *Frontogenesis Within a Moving Deformation Zone*



# *Factors Affecting Frontal Intensity*

- Convergence and Divergence
  - Low-level convergence always supports frontogenesis, but does not guarantee it.
    - Dynamics associated with PFJ is critically important.
    - Divergence aloft, supports frontogenesis.

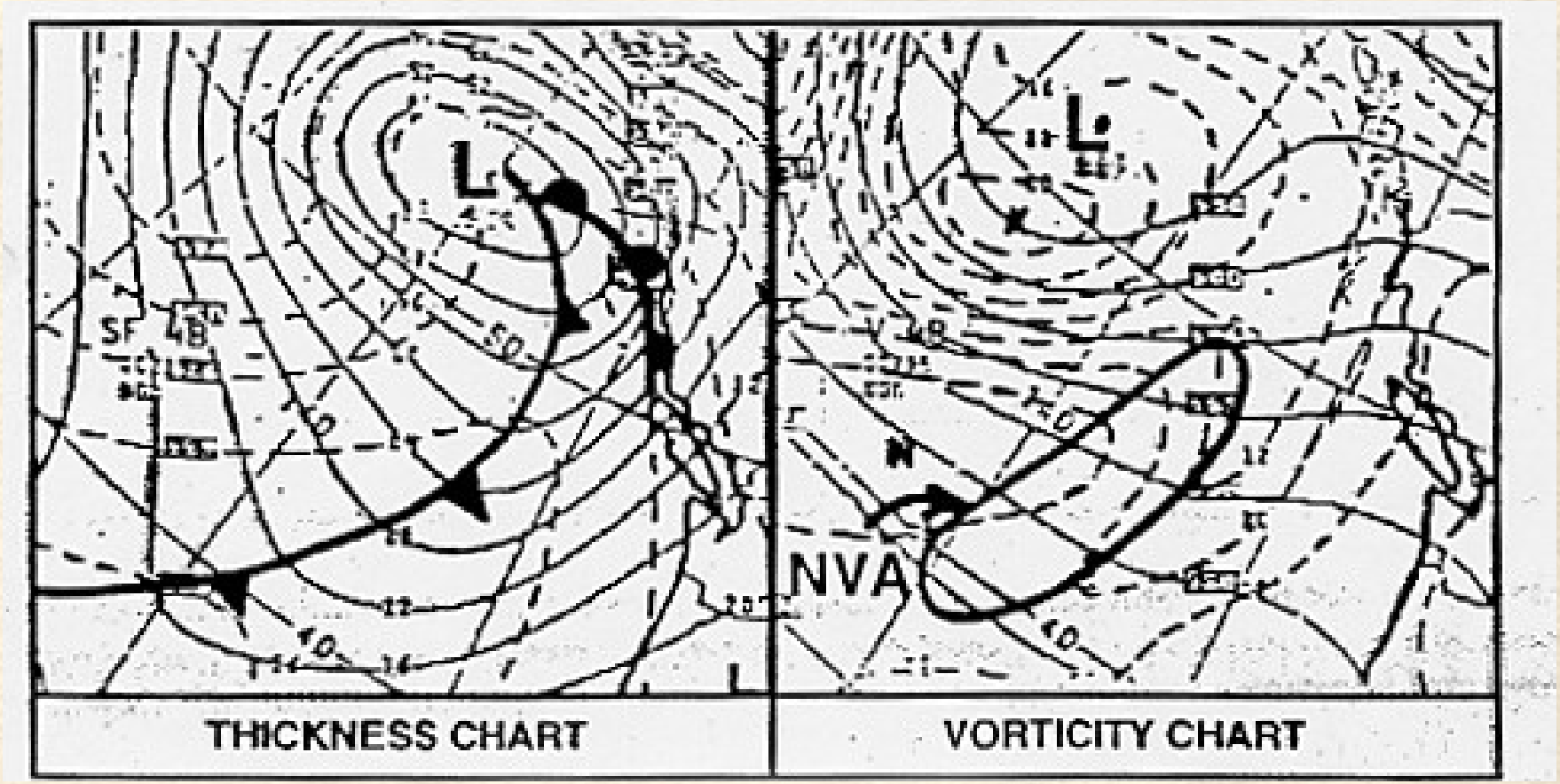
# *Divergence Aloft Supporting Frontogenesis*



# *Factors Affecting Frontal Intensity*

- Low-level divergence always supports frontolysis, but does not guarantee frontolysis.
  - Dynamics associated with PFJ critically important.
  - Convergence aloft, supports frontolysis.

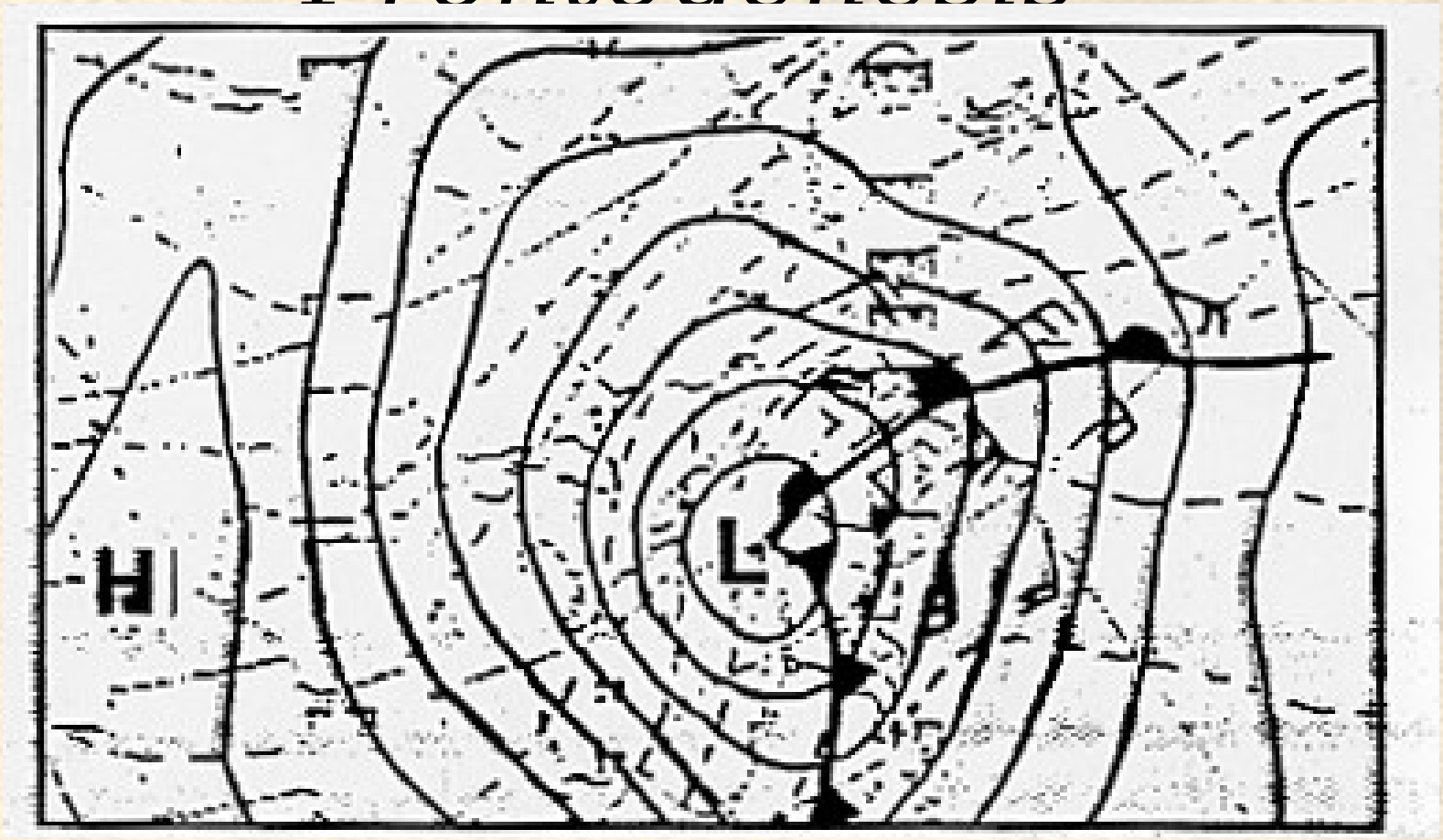
# *Convergence Aloft Supporting Frontolysis*



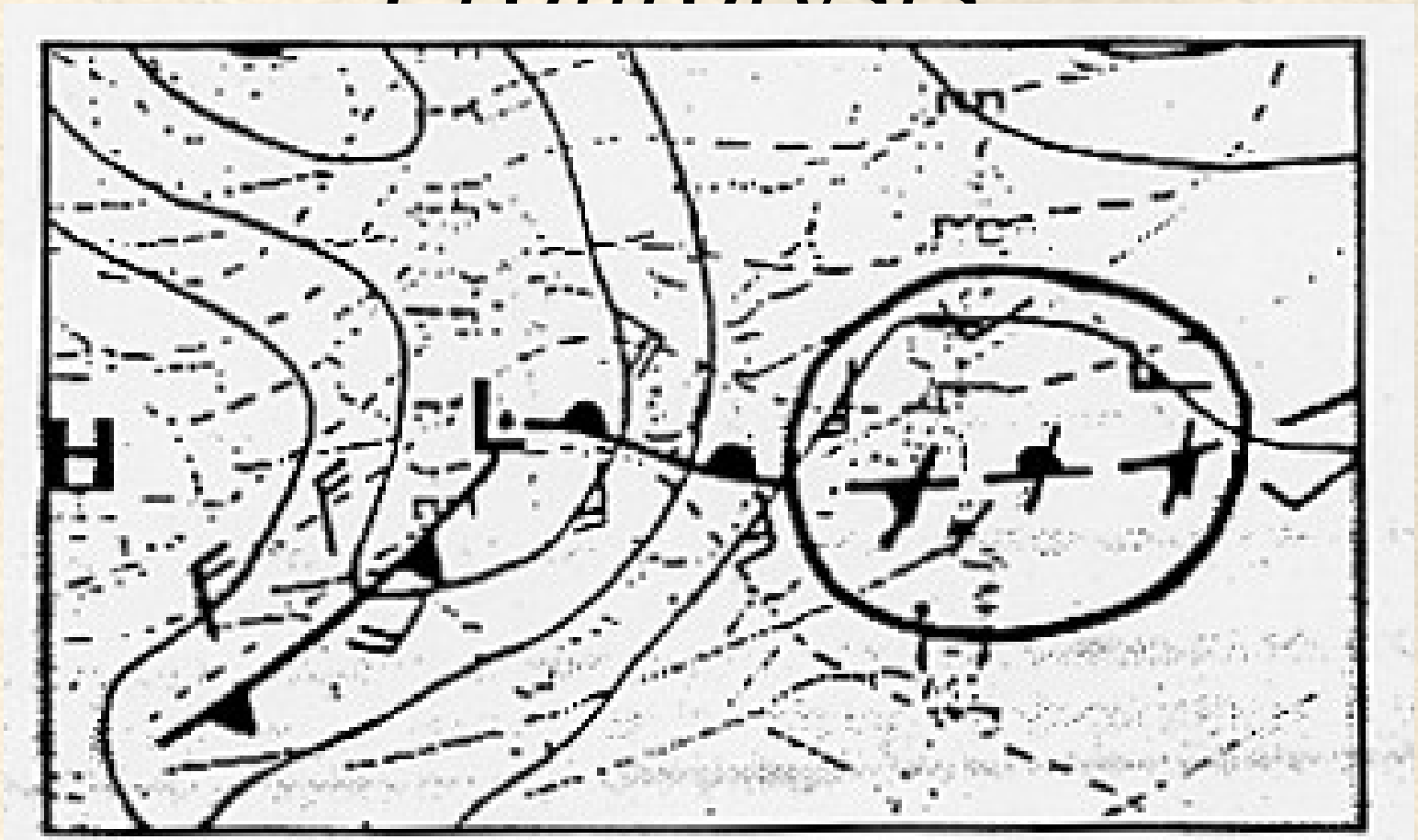
# *Factors Affecting Frontal Intensity*

- Cyclonically curved flow in boundary layer leads to low-level convergence.
- Sharpening of cyclonic turning will strengthen front.
- Anticyclonically curved flow in boundary layer leads to low-level divergence.
- Low-level wind turning anticyclonically will **undergo** enhance frontolysis.

# Boundary Layer Convergence Supporting Frontogenesis



# Boundary Layer Divergence Supporting Frontolysis

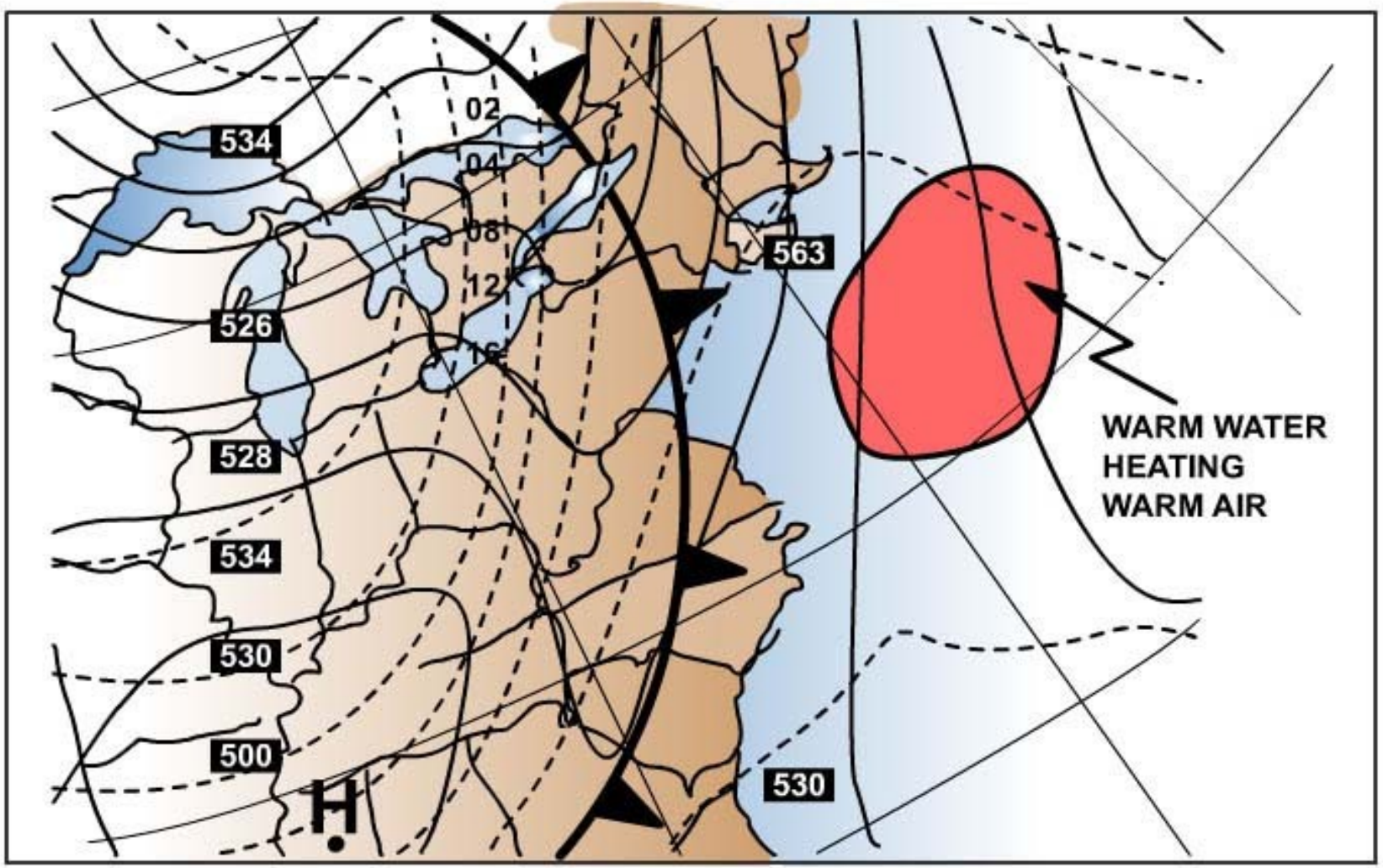


# *Factors Affecting Frontal Intensity*

- Diabatic Effects
  - Definition - Diabatic process involves exchange of energy (heat) between air parcels and their environment.
    - Diabatic processes includes heat exchange due to latent heat release, evaporative cooling, conduction, radiation, etc….

# *Factors Affecting Frontal Intensity*

- Frontogenesis is supported if warm air is heated or cold air is cooled.
  - Air masses form in source regions from this diabatic effect

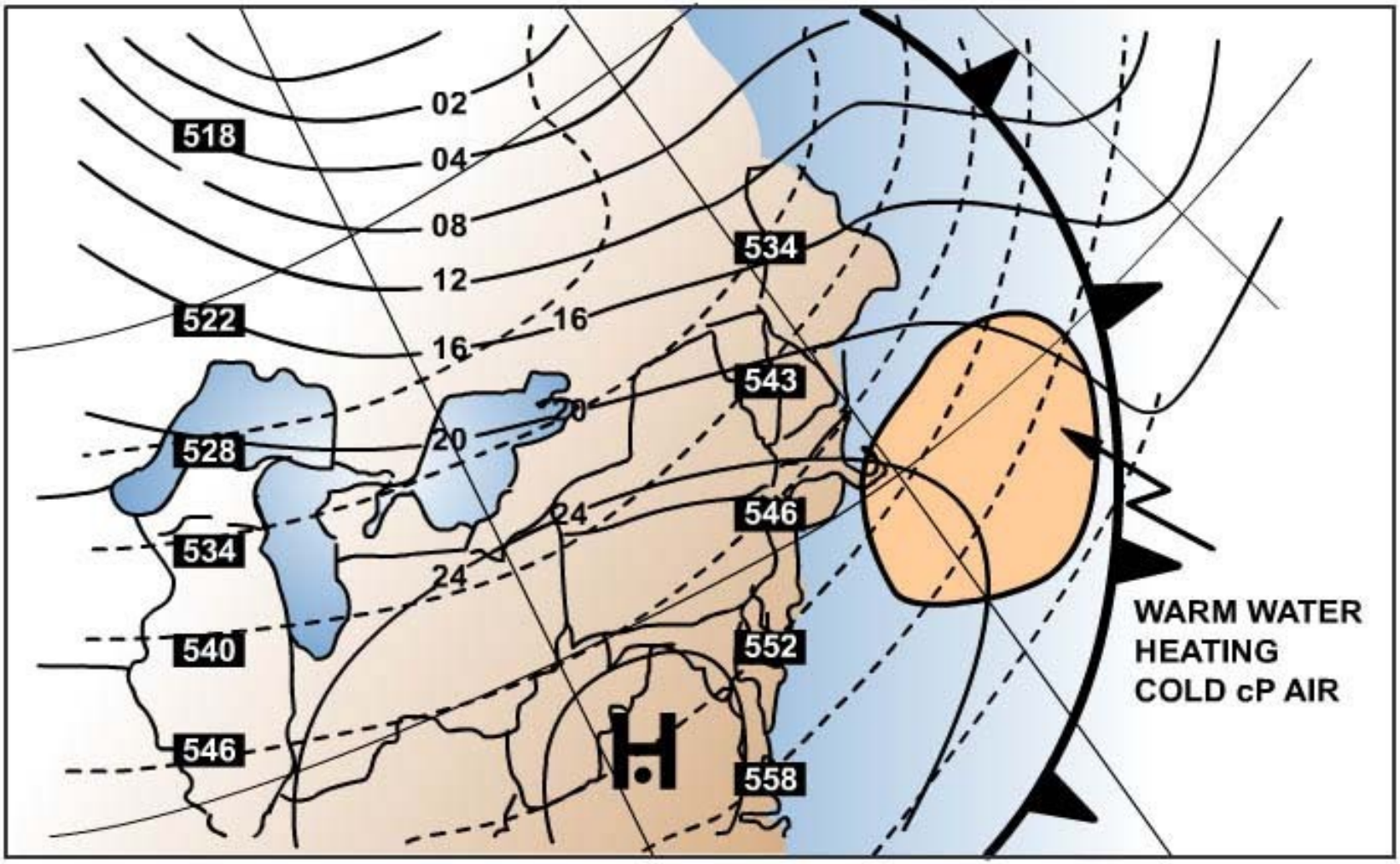

534
526
528
534
530
500
H
02
04
08
12
16
563
530
WARM WATER
HEATING
WARM AIR

# *Factors Affecting Frontal Intensity*

- Outside source regions, situation is not as common, but may still happen in various situations.
- If this differential heating enhances the thermal contrast, frontogenesis will be enhanced.

# *Factors Affecting Frontal Intensity*

- Frontolysis is supported if cold air is heated or warm air is cooled from below.
  - Air masses experience modification as they move outside of source regions.
  - Modification is further enhanced as cold air moves equatorward and warms.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546
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558
H
WARM WATER
HEATING
COLD cP AIR

# *Factors Affecting Frontal Intensity*

- If any combination of the above factors are present then:
  - If all factors are supporting frontogenesis or frontolysis then significant intensification or dissipation will occur.
  - If some factors oppose one another, then change in frontal intensity will be small and difficult to estimate without the aid of a computer forecast model.
  - Continuity from quality analyses is essential for tracking the intensity of fronts.

# *Factors Affecting Frontal Intensity*

- Numerical models are useful tools, combined with good meteorological reasoning, climatology, and forecaster experience, to aid in evaluating the future evolution and movement of fronts.
- Strength of front determines how significant the change in the weather may  be across the frontal boundary.

# *Factors Affecting Frontal Intensity*

- Fronts experiencing frontogenesis are more likely associated with strengthening ascent and increasing coverage of clouds and precipitation.
- Fronts experiencing frontolysis are more likely associated with weakening ascent or actual descent and decreasing coverage (or total absence) of clouds and precipitation.

- APPLICATION:
- EVALUATION: